Woolley, 1945 : Two units in biology

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Master's Paper

TWO UNITS IN BIOLOGY

Submitted by

Esther Joy Woolley
(A.B., Tufts, 1931)

In partial fulfillment of requirements for
the degree of Master of Education
1945

First Reader: Roy O. Billett, Professor of Education
Second Reader: George K. Makechnie, Professor of Education
Third Reader:

✓

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CHAPTER I

INTRODUCTION

Biology in a Small High School

Prevailing conditions.-- This unit is the outcome of the dissatisfaction on my part with the work being done in my biology classes in a small high school of about 500 students.[1] The biology course is offered in the tenth grade of a four-year high school. There is no grouping of pupils according to ability and about 70 per cent of the pupils in the tenth grade elect biology. Because of the fact that the town in question has private schools for girls and for boys to which townspeople may send their children without tuition charges, not many pupils who attend high school are of college caliber. Those we do have come from the homes of office workers, small merchants, farmers, and workers on tobacco plantations. Many of the pupils do not finish high school and about 10 per cent of the graduates go on to schools of higher education.

Changes introduced.-- The pupils have been accustomed to using one textbook only. One text is all that they

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[1] This dissatisfaction was in part caused by the writer's taking a course in the Unit Assignment and reading Fundamentals of Secondary School Teaching by Roy O. Billett. This paper is an effort to apply the principles gained from Dr. Billett.

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consider necessary in any subject and that is to be taken ex cathedra. The abolishing of this idea cannot take place in a short time but a modification of the unit assignment can eventually develop those objectives which have recently been expressed in the Thirty-first Yearbook, Part I, National Society for the Study of Education,[1] and by Beauchamp.[2] At the same time the material would be presented in a more interesting manner to the students, thus bringing more satisfaction to the teacher in her work.

Consequently, the ideas that cover the material on reproduction and heredity were assembled last summer and the unit was delimitated. To ensure that the pupils would learn the desired material a mimeographed copy of the core and optional activities was given to each pupil. Various biology textbooks were in the classroom and the pupils had access to them at all times.

At first many of the pupils tried to find all the material in one text, but after a short time, as a result of the teacher's suggestions, they began to use more texts and other related materials. Because this type of work with more than one text is new to the pupils and to the parents, it was felt

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1/ The Thirty-first Yearbook of the National Society for the Study of Education, Part I, A Program for Teaching Science, Public School Publishing Company, Bloomington, Illinois, 1932, p. 224-226.

2/ Wilbur L. Beauchamp, Teacher's Guidebook for "Everyday Problems in Biology," Scott, Foresman and Company, New York, 1934, p. 6-8.

that the pupils should begin making an outline of the material they were reading and that this should be started about the second week of the unit.

This unit was given to the students the last week in September and covered six weeks' work. They had had two and one-half weeks of the subject before the unit was started. Thus the students were presented with one of the most difficult units very early in the course of the year's work. About one fifth of them had had no science the previous year. Despite these facts, the students enthusiastically worked on the unit and were desirous of continuing this type of work for the rest of the year. The results which were shown on the test and the enduring interest of the pupils more than justified the venture of presenting the material in the manner described.

CHAPTER II

REPRODUCTION AND HEREDITY

Unit and Test

The unit.-- One of the characteristics of living things is their ability to give rise to other living things similar to themselves. There are two main types of reproduction. Offspring which are produced by a single parent without the union of two cells are said to be produced asexually. Offspring which are produced by the union of two sex cells are said to be produced sexually. In the first type the offspring cannot help being like its parent; whereas, in the second type, the offspring can inherit characteristics from both its parents and from the ancestral lines. The transmission of characteristics, known as heredity, is a recent study but one which is even now economically and socially of vital importance.

Delimitation of the unit.--

1. Life comes from life.
2. All living things begin life as a single cell.
3. Everything that an organism is to have is present in the germ cells of its parents.
4. There are two types of reproduction, asexual and

sexual. Each type has its advantages and its disadvantages. Sexual reproduction allows for variation and change.

5. Many times vegetative reproduction is economically and scientifically more expedient.
6. Nature has many methods to insure future generations.
7. Parental care increases the chance of survival of the species.
8. The laws of heredity are fairly well known. The improvement in existing species and the production of new species show how these laws have been applied.
9. The laws of heredity have been found to apply to all living things, including man. A knowledge of the laws of heredity gives the individual a better understanding of himself in relation to his fellow beings.
10. Life is not stationary. Inherited changes have taken place over a long period of time. Life is always going on, but within certain limits man can determine and improve it.

Incidental and indirect learning products.--

1. A respect of the complexity of factors that determine the life of an organism.
2. An appreciation of the forms of an organism.

3. Proper terminology for parts and processes as applied to reproduction and heredity.

Suggestions for evaluating the unit.-- [illegible]

1. Does a pupil take care of or raise any plants or animals and profit by the ideas gained in the study of this unit?
2. Is there evidence of an increased vocabulary of frequently used new terms?
3. Is there any evidence of an interest in family trees?
4. Does the pupil give evidence of mastery of the processes?
5. Does the pupil realize the importance of the laws and principles of heredity?
6. Does the pupil possess a common-sense idea of the origin of life?

List of Readings for Teacher's Use Only.--

1. Hunter, George W., "An Experiment in the Use of Three Different Methods of Teaching in the Classroom," *School Science and Mathematics*, Vol. 21, p. 875-890; Vol. 22, p. 20-24.

2. Morgan, Thomas Hunt, *The Scientific Basis of Evolution*, W. W. Norton and Co., New York, 1935. 286 p.

3. Newman, H. H. ed., *The Nature of the World and of Man*, Garden City Publishing Co., Garden City, New York, 1933. Chapters 6, 8, 13, 14, 15.

4. Scheinfeld, Amram, *You and Heredity*, Frederick A. Stokes, New York, 1936. 434 p.

5. Sinnott, E. W. and Dunn, L. C., Principles of Genetics, Mc-Graw Hill, New York, 1939. 408 p.

6. Terman, Lewis M. and others, Genetic Studies of Genius, Vol. I, Mental and Physical Traits of a Thousand Gifted Children, Stanford University Press, Stanford University, California, 1926. 605 p.

7. Wells, H. G., Huxley, Julian S., and Wells, G. P., Science of Life, Doubleday, New York, 1934. 1514 p.

8. Woodring, Maxie Nave, Oakes, Mervin E., Brown, H. Emmett, Enriched Teaching of Science in the High School, Bureau of Publications, Teachers' College, Columbia University, New York, 1941. 402 p.

The Unit Assignment.-- (Time allotment, five weeks, five periods per week.)

A. Introduction: Pictures of baby kangaroos were shown to the class and these little inch and a quarter creatures formed the basis of many questions and stirred up a great deal of interest in animals. Some of the pupils showed a decided interest in the queer animals that come from Australia and why the animals are found only in that region.

B. For individual study and investigation:[1]

Core Activities

1. By means of either the microscope slides or lantern slides observe the parts of some mold. Make a simple diagram showing the parts and briefly trace the life cycle of the mold plant from the time a spore begins to grow until new spores are formed.
2. Observe the runners or stolons of a black mold and the

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[1] The items in B were reproduced in a mimeographed study and activity guide of which each pupil received a copy.

runners of a strawberry plant. Sketch a diagram of a plant to show how the plants rise by means of runners. Label the parent plant and the runners or stolons.

3. Examine the specimens of the plants in the school terrarium to discover those which are able to produce a new plant without the aid of a second plant. List those that you find.

Material to be answered in your notebook:

4. "Vegetative reproduction" refers to one part of a plant when separated from the other parts growing the parts which are missing. What are six vegetative ways of reproduction? How do you distinguish them?
5. What other methods are there in addition to vegetative ones of asexual reproduction?
6. What are three forms of asexual reproduction in plants?
7. Examine slides with the aid of the microscope (demonstration set-up) which exhibit cells in different states of cell division. Discuss what is seen in the light of what has been said about this process.
8. Examine spirogyra conjugating. Look at it on the screen from the microprojector and in the prepared microscope slides. Locate the main parts. Draw and label.
9. Look at a slide of a conjugating paramecium to observe the detailed structure. Make a drawing of this and label the parts.

10. What is conjugation? Why is it considered a sexual method of reproduction?

11. Why is the alternation of generations of the mosses considered a transition between the sexual methods of flowering plants and higher animals and the asexual methods of lower plants and animals?

12. How do you distinguish the following in a moss plant: sporophyte generation, antheridium, archegonium, gametophyte generation, protonema?

13. Draw the following parts of a moss plant: protonema, antheridial plant, archegonial plant, archegonial plant with the sporophyte attached, seta, capsule.

14. Using the charts on the flower and the diagrams in the textbooks observe the states in the life cycle of a flowering plant. Locate parts of the flower indicated on the printed sheet which is obtained from the cabinet in the back of the room. Parts indicated are pollen grain, anther, stamen, stigma, style, ovule, megaspore, fusion nucleus, egg cell, sperm nucleus, egg.

15. Trace the development of a seed after the fertilization of its ovule.

16. What factors are necessary for germination?

17. Examine the bean seeds that have been soaked over night. Look at the outside of the seed carefully and then remove the seed cover and spread open the cotyledons.

Make two sketches -- one an edge view of the bean seed before the cover was removed, and the other an internal view. Label the parts in both diagrams.

18. Do likewise with a corn seed; except when you remove the covering there will not be two sections as in the bean.
19. What is the purpose of each of the internal parts of the bean seed?
20. What differences are there between the parts of a bean seed and those of a corn seed?
21. In what four different ways are seeds dispersed?
22. From the dissected model of a fish make a drawing showing the testes or the ovaries (whichever is shown), the swim bladder, the kidneys, the urinary bladder, and the intestines.
23. Make a drawing of the reproductive organs of a frog from the dissected models. Label the parts.
24. What are the main parts of a mammalian embryo? What is the purpose of each?
25. What is meant by the period of gestation?
26. How does a mammalian embryo receive its food?
27. What is the difference between an oviparous and a viviparous animal?
28. What is meant by an unisexual organism as distinguished from a bisexual one? Give an example of each.

29. What is the meaning of these terms: gamete, fertilization, ovum or egg cell, sperm, zygote, embryo?

30. What is one example of strong parental care among the insects? Give sufficient material to show the care given by the "parents."

31. In general how does parental care among mammals compare with that of lower animals?

32. What do you understand is meant by heredity?

33. What are chromosomes? Is the chromosome number of a species always constant?

34. What are genes?

35. How is a certain character such as straight hair passed on to a succeeding generation?

36. Use two different colors of beans, grains of corn, or squares of colored paper. Put equal numbers of the two colors in various dishes. Work in groups of two or three. One pupil should draw out at random from the dish two of the items at a time. Another student should tabulate the results of each drawing under one of the three possible combinations. The data from the entire class will be collected and the approximate ratio will be determined. This illustrates the case where only one pair of genes without dominance is considered.

37. This experiment is to illustrate the case where only

one pair of genes with dominance is considered. Proceed as in No. 36, except it must be remembered that, if one or more of the grains of corn or the like, representing the dominant trait, is drawn, the color or character will be of the dominant type. The data from the entire class will be collected and the approximate ratio determined. (Warning! In these two experiments the ratio is not true for small numbers.)

38. What is Mendel's law of dominance expressed in your own words?

39. What is Mendel's law of segregation?

40. What is the law of independent unit characters?

41. What is a mutant or sport?

42. What is meant by inherited traits as distinguished from acquired traits?

43. What was proved by Weismann's experiment in which he cut off the tails of several generations of rats?

44. What is meant by the principle of selection in plant or animal breeding?

45. B is dominant (Black); w is recessive (white). Bw and ww are crossed. Theoretically out of four offspring, how many will appear black? How many will appear white? How many will be hybrids?

46. If red is dominant in a flower and white is recessive, why do pink flowers of this species occur?

47. Explain the following: (1) Unbranched sunflowers continue to produce unbranched offspring, but branched sunflowers often yield seeds which produce unbranched sunflowers. (2) Once in awhile a human albino appears in some family.

48. How may a breeder use hybridization for the improvement of plants or animals?

49. What have you noticed about the stability of hybrids?

50. What conclusions do you draw from a study of the Kallikak and the Edwards families?

51. How do you account for the fact that a child may have light hair, blue eyes, and a light skin while its parents have none of these characteristics?

52. Discuss the reason why color blindness is more common among males than among females.

53. What danger is involved in close intermarriages?

54. How do you distinguish between eugenics and euthenics?

Optional Activities

1. Follow the direction given in Dynamic Biology, page 581, and graft a stem upon a growing tree or upon branches that can be brought into the laboratory. List five steps in grafting. Make a drawing to show a bud inserted in the original plant (the stock).

2. Bring into class samples of grafting. Write a report on the various methods. Material is listed in the

library under Grafting.

3. Is it possible to raise apples from a branch which has been grafted on to a peach tree? Investigate the kinds of plants which may be grafted on others.
4. Prepare a demonstration of the forming of new plants without the use of seeds, using willow stems, slips from a geranium, and ferns. This will necessarily require observation over an interval of weeks.
5. As a result of your visit to the florist's make a report on how geraniums are raised in the greenhouse. Look up extra material for this report in the books on Horticulture in the school library.
6. Write a brief summary of George Washington Carver's work with the sweet potato or the peanut. This material can be found in the school library in a book on the life of Carver.
7. If living specimens Planaria dorotocephala are available, devise and perform some regeneration experiments. Observe the results over a period of days.
8. Examine some slides of cell division (mitosis) in onion root tips. With the aid of the instructor, identify cells in different stages of mitosis. Lantern slides exhibiting different stages of mitosis may also be used.
9. After a visit to the Connecticut Experimental Station to see soil tested, write a report so that the entire

class will benefit from your visit. Soil will be tested for suitability to growing a given plant.

10. Visit a large nursery and make inquiry about the methods used in growing maple trees. Write up the information you received from this visit and report it to the class.
11. Collect, classify, and label: Flowers of trees, seedlings, staminate and ovulate cones.
12. Collect 50 seeds of one kind of plant, i.e., black beans; assort them according to size; make a record of your groupings and tell which ones you would select to plant and why.
13. Pollinate the ripe stigma of a lily. Let it stand twelve hours. Slice a thin layer of the stigma. Place on a glass slide with a few drops of water; mash; cover with cover glass and look through microscope to observe the sprouting of the pollen granule.
14. After examining Gager, C. S., General Botany, McDougal, W. B., Plant Ecology, Smith, G. M. and others, Textbook of General Botany, prepare a report on the adaptations for pollination exhibited by sweet peas, nasturtiums, and other flowers.
15. In addition to sweet cherries, what other plants can you discover that are unable to self pollinate and produce seeds?

16. Sprout various seeds in window boxes. By varying conditions of moisture and kinds of soil, try to determine factors which are favorable to sprouting. Devise an additional experiment to determine whether or not light is necessary for the sprouting of seeds.

17. Plant some bean seeds and some corn seeds in boxes. Give them the same amount of water but put some of the boxes where they do not get direct sunlight. Keep a record of their growth and make a simple chart of this.

18. After reading some of the successful work of Luther Burbank, pick out some of the most interesting cases and write a report on them.

19. Plan and perform an experiment of your own to show that maggots (fly larvae) are not generated spontaneously, but hatch from flies' eggs laid upon organic material such as decaying meat.

20. Keep some guppies (small viviparous fish) in a special aquarium. Study their habits of reproduction. Note the ratio of survival of the offspring. How frequently are young produced? Is this type cannibalistic? Consult Hegner, R. W., College Zoology.

21. Determine the approximate number of eggs within the body of a female fish. Obtain a fish with eggs (roe). Remove the eggs and boil them. Then weigh ten or twenty of the eggs. Now weigh the entire mass of boiled eggs

and calculate the total number of eggs from the figures you have obtained.

22. Investigate by reading (a) the average number of offspring, (b) the length of the period of immaturity, and (c) the probable number of offspring that reach maturity in each of the following organisms: grasshopper, oyster, codfish, rabbit, rat, and elephant.

23. From back issues of magazines make a collection of pictures that show the reproduction of animals.

24. Prepare models of clay or charts illustrating cleavage in a sea urchin. Models of the blastula and the gastrula are also desired. The same can be done for a frog.

25. Investigate reproduction in the domesticated chicken. What is meant by incubation? What is the period of incubation of a hen's egg? What is the body temperature of a hen? Is this temperature maintained in an incubator? Boil a fertilized egg and locate the embryo on the surface of the yolk. Write an account of your investigation.

26. A biologist classifies organisms according to their structural similarities. In several bottles closed with wads of cotton, raise some fruit flies, using fruit as food. Study their life history and characters. Look up Morgan's experiment with these organisms.

27. Prepare an exhibit which illustrates the principle of

variation. Select some species of plant and gather a large number of specimens which are all of the same species. Study the material. Are there any two that are exactly alike? Mount the specimens upon a display board for the inspection of the class. Make a collection of leaves, seed, fruits, or flowers. In each case use only one species. Study them for evidences of variation.

28. Suggestions for Posters:
    a. Life cycles of moss, fern, pine tree, and any typical flowering plant.
    b. Mounted collections of pictures may be made to show seed and fruit dispersal.
    c. Pictures of animals that exhibit strong or unusual parental care may be assembled and mounted.
    d. Charts showing the embryos of fish, amphibians, reptiles, birds, and mammals.
    e. Diagrams showing the stages in the development of a chick embryo.
    f. Pictures or sketches of specimens of the same species to show variation. A separate cardboard should be used for each species.
    g. A diagram in color to illustrate incomplete dominance in the Andalusian fowl.
    h. Collections of pictures may be mounted for the

purpose of comparing wild or uncultivated plants with the improved varieties, and for the purpose of showing the value of animal breeding.

29. Demonstrations:

    a. Specimens of mold. Put slices of moist bread in a dark place. Watch daily for growth of mold.
    b. Collect strawberry plants, blackberry plants, and onion plants for demonstrations of runners, layering, and bulbs.
    c. Bring in samples of grafting.
    d. Collect early in the fall sufficient number of mosses and liverworts for the terrarium and for class work.
    e. Specimens of seeds and fruits may be collected from weed stems, bushes, and trees and sorted into groups according to their methods of distribution. Some of the lighter winged seeds may be released to show how easily they fly about.
    f. Bring in to class several good ears of corn in contrast with a few stunted ears that may be studied from the standpoint of use for planting.
    g. Specimens of wild or uncultivated fruits and their improved or domesticated relatives may be collected for comparison. A discussion of the methods of improvement should accompany each.

h. For the purpose of showing the effects of heredity the following exhibits: smooth and wrinkled pea seeds, mounted specimens of red, pink, and white four-o'clocks, and pictures of guinea pigs.

i.. The hatching of frogs' eggs and the subsequent development of tadpoles.

j. Preserved specimens to show the embryological development of the chick.

k. Preserved specimens to show the development of the mammalian embryo.

l. For the purpose of illustrating the chance combination of genes in the transmission of unit characters, mix together 48 red beads and 48 white beads. Have one pupil close his eyes and draw out two beads at a time; have another pupil record the colors that are drawn each time. When all the beads are withdrawn, tabulate the number of times the pupil drew two red beads, two white beads, and one red bead and one white bead. Thinking of these beads as genes, record how many times you get each combination:

RR.......... RW.......... WW..........

List of Readings and References for Pupils' Use.--

A. Library Books

1. Baitsell, George Alfred, Ed., Evolution of Man, Yale University Press, New Haven, 1922. 160 p.

2. Blatz, W. E., *The Five Sisters*, William Morrow and Co., New York, 1939. 209 p.

3. Buchsbaum, Ralph, *Animals without Backbones*, University of Chicago Press, Chicago, 1938. 371 p.

4. Comstock, Anna B., *Handbook of Nature Study*, Comstock Publishing Co., Ithaca, N. Y., 1939. 938 p.

5. Crampton, Henry Edward, *Coming and Evolution of Life*, University Society, New York, 1931. 103 p.

6. Davenport, Charles B., *How We Inherit Our Bodies*, Henry Holt and Co., New York, 1936. 401 p.

7. Dunn, L. C., *Heredity and Variation*, University Society, New York, 1931. 120 p.

8. Furnas, C. C., *The Next Hundred Years*, Blue Ribbon Books, New York, 1936. 434 p.

9. Haggard, Howard W., *Man and His Body*, Harper and Brothers, New York, 1938. 549 p.

10. Hegner, Robert, *Parade of the Animal Kingdom*, Macmillan, New York, 1940. 675 p.

11. Jewett, Mrs. Frances (Grulick), *Next Generation*, Ginn and Co., New York, 1924. 235 p.

12. Johnson, Gaylord, *How Father Time Changes the Animals' Shapes*, Julian Messner, Inc., 1939. 183 p.

13. Keliher, Alice V., *Life and Growth*, Appleton-Century, New York, 1941. 245 p.

14. Knott, James E., *Vegetable Gardening*, Lea and Febriger, Philadelphia, 1941. 352 p.

15. Llwellyn, Richard, *How Green Was My Valley*, Macmillan, New York, 1942. p. 282-288.

16. Locy, William Albert, *Biology and Its Makers*, 3rd ed. rev., Holt, New York, 1915. 469 p.

17. Loomis, Frederick Brewster, *Evolution of the Horse*, Marshall Jones Co., Boston, 1926. 205 p.

18. Newman, H. H., Freeman, F. N., Holzinger, K. J., *Twins*, Ginn and Co., New York, 1939. 276 p.

19. Reed, W. Maxwell, and Lucas, Jannette M., Animals on the March, Harcourt, Brace & Co., New York, 1937. 285 p.

20. Rice, Thurman, B., Living, Scott, Foresman and Co., New York, 1940. 329 p.

21. Strain, Frances Bruse, Being Born, Appleton-Century, 1937. 144 p.

22. Thomson, J. Arthur, Sir, Ed., The Outline of Science, G. P. Putnam's Sons, New York, 1937. 4 vol.

23. Zim, Herbert S., Mice, Men, and Elephants, Harcourt, Brace and Co., New York, 1942. 296 p.

B. Textbooks

1. Baker, A. C., Mills, L. H., Dynamic Biology, Rand McNally Co., Chicago, 1935, p. 573-656.

2. ________________, Dynamic Biology Today, Rand McNally and Co., Chicago, 1943, p. 180-183, 540-615.

3. Hunter, George W., New Essentials of Biology, American Book Co., 1928, p. 65-68, 191-193.

4. Moon, Truman J. and Mann, Paul B., Biology for Beginners, Henry Holt and Co., New York, 1934, p. 117-125, 155-171, 202-204, 365, 449-454, 668-688.

5. Pieper, Charles J., Beauchamp, Wilbur L., Frank, Orlin D., Everyday Problems in Biology, Scott, Foresman and Co., New York, 1935, p. 108-114, 134-137, 152-189, 429, 509-551.

REPRODUCTION AND HEREDITY

Part One. True-False Test

Directions. In the right-hand margin after the number of the statement write the word true if you believe the statement to be true and the word false if you believe the statement to be false.

Sample:

1. Dogs are one kind of animal. 1. .true..

1. Toads sometimes develop from soft stone. 1. ....
2. Some snakes grow from a horse's hair dropped in a pail of milk. 2. ....
3. A kitten starts out living as five compact cells. 3. ....
4. In its beginning a seed is only one cell. 4. ....
5. If a person is to have the ability to become a famous pianist, he is born with that ability. 5. ....
6. A mule may develop humps like a camel. 6. ....
7. A corn seed after it is planted can be made to bear beans by changing the chemicals which are given it when it is developing. 7. ....
8. Intelligence is thought to be inherited. 8. ....
9. Male frogs are needed to fertilize the eggs from the females. 9. ....
10. The embryo of a human being is easily recognizable from that of a rabbit when both are half way in their respective developments. 10. ....
11. A fetus is formed in the development of a bird. 11. ....
12. Eggs are produced only by birds. 12. ....

13. The seed of an oak tree has nine large cells. 13. ....

14. A tobacco seed consists of a fertilized cell. 14. ....

15. A bean seed contains only a small plant. 15. ....

16. Not all seeds develop when properly planted. 16. ....

17. Seeds sometimes may be kept a long time and then germinate when properly planted. 17. ....

18. The pollen of a flower is used in forming a seed. 18. ....

19. The simplest method of reproduction in plants is by means of seeds. 19. ....

20. Imperfect flowers are those whose petals are not of the right color or shape. 20. ....

21. The "eyes" of a potato are often planted to produce new potato plants. 21. ....

22. In a biological sense conjugation refers to grafting two plants. 22. ....

23. The character of the flower or fruit that grows from the scion is affected by the stock. 23. ....

24. Many higher plants may develop in ways other than by means of seeds. 24. ....

25. The tendency to produce more offspring

than can survive is characteristic of only a few species of living things. 25. ....

26. In general, hybridization can be carried out more easily when the parent plants are closely related. 26. ....

27. Plants do not care for their young. 27. ....

28. Mutants appear more frequently among animals than among plants. 28. ....

29. Mutations are caused by gradual changes in the germ plasm of a cell. 29. ....

30. An example of a sex-linked characteristic is color-blindness. 30. ....

31. Variations cannot be transmitted to offspring. 31. ....

32. Mutations are caused by changes affecting the germ plasm. 32. ....

33. When an organism acquires certain characteristics as a result of the influence of the environment, only the germ plasm is affected. 33. ....

34. Cats produce only kittens and not sometimes a guinea pig. 34. ....

35. Some people are born with tuberculosis. 35. ....

36. A person can inherit a certain characteristic from his great-grandparents. 36. ....

37. If a mother thinks about a curly-haired baby, her baby will have curly hair. 37. ....

38. A blue-eyed mother and a blue-eyed father can produce only blue-eyed offspring. 38. ....

39. Brown-eyed parents cannot have blue-eyed children. 39. ....

40. Abnormal characteristics of freaks are transmitted to their offspring. 40. ....

Part Two. Multiple Choice

Directions: The following statements have four or five endings. Only one of these is correct. You are to select the one which you believe makes the statement true. In the right-hand margin you are to put the letter which precedes the ending you have selected.

Sample:

1. In the human body tissues are grouped together to form
   a. cells
   b. protoplasm
   c. organs
   d. muscles 1. ..c..

---

1. A dog starts living as
   a. a puppy
   b. a single cell
   c. an egg
   d. seven cells 2. .....

2. The stage in the development of an insect which immediately follows fertilization is the

a. adult

b. gastrula

c. egg

d. blastula 2. .....

3. The development of embryos from unfertilized eggs is termed

a. oögenesis

b. parthenogenesis

c. hermaphroditism

d. metamorphosis 3. .....

4. The state of an embryo which most closely resembles a hollow ball is the

a. gastrula

b. blastula

c. egg

d. zygote 4. .....

5. In a plant the number of reproductive cells formed is

a. small

b. large

c. dependent upon the weather

d. single 5. .....

6. The female reproductive cell is called the

a. egg

b. sepal

c. sperm

d. anther 6. .....

7. An Easter lily seed started out with

a. one cell

b. three cells

c. twenty-one cells

d. no cells 7. .....

8. The point of attachment of a seed to the pod is the

a. microphyl

b. hilum

c. testa

d. scar 8. .....

9. Endosperm, embryo, and seed covering make up a

a. flower

b. tree

c. seed

d. microörganism 9. .....

10. A seed is a

a. living thing

b. non-living thing

c. mixture of chemicals

d. molecule 10. .....

11. Primarily flowers are for the purpose of

a. accomplishing reproduction

b. creating beauty

c. providing vegetables

d. strengthening the plant 11. .....

12. A perfect flower is defined as one with

a. both stamen and pistil in the same flower

b. all floral parts present in the same flower

c. the petals of perfect color

d. the petals of perfect shape 12. .....

13. The sepals of a flower are known as the

a. petals

b. calyx

c. corolla

d. stamen 13. .....

14. The process of cell division in higher animals is called

a. fertilization

b. mitosis

c. conjugation

d. amitosis

e. segregation 14. .....

15. Growth in the bodies of higher plants and animals takes place by

a. fertilization

b. mitosis

c. conjugation

d. amitosis

e. aëration 15. .....

16. The tissues which must be united in grafting are the

a. epidermis

b. parenchyma

c. cambium

d. mesophyll 16. .....

17. "Layering" in plants refers to

a. a section in a plant

b. a type of vegetative reproduction

c. the habitats of the plant

d. a way of grafting 17. .....

18. Raspberry bushes usually multiply by means of

a. seeds

b. runners

c. spores

d. conjugation 18. .....

19. The theory of mutation was first advanced by

a. Charles Darwin

b. Gregor Mendel

c. August Weismann

d. Luther Burbank

e. Hugh de Vries 19. .....

20. The theory of natural selection is an attempt to explain

a. new species

b. improvement of a species

c. acquired characteristics

d. overpopulation 20. .....

21. Hornless cattle have come into existence by

a. hybridization

b. the efforts of Hugo de Vries

c. selective breeding

d. mutation

e. the principle of incomplete dominance 21. .....

22. A scientist known for his work on heredity is

a. Pasteur

b. Carrell

c. Mendel

d. Reed 22. .....

23. If pure-stock tall peas are crossed with pure-stock dwarf peas, the descendants in the F_1 generation will

a. all be tall hybrids

b. be 50 per cent tall

c. be 75 per cent tall

d. be 25 per cent tall

e. all be short hybrids 23. .....

24. Mendel's primary purpose in his experiments was to determine

a. the best methods of cultivating peas

b. the value of mutants in plant breeding

c. what unit characters parents contribute to offspring

d. the significance of selective planting

e. why peas breed true to seed 24. .....

25. In the process of straight cell division daughter cells always have

a. half the number of chromosomes as the parent cells

b. the same number of chromosomes as the parent cells

c. twice the number of chromosomes as the parent cells

d. a less number of chromosomes than the parent cells

e. a greater number of chromosomes than the parent cells 25. .....

26. In the process of maturation the eggs and sperms always receive

a. half as many chromosomes as the germ cells have

b. the same number of chromosomes as the germ cells have

c. twice as many chromosomes as the germ cells have

d. a greater number of chromosomes than the germ cells have

e. twenty-four chromosomes 26. .....

27. Two children of the same parents, reared under the same conditions, are

a. always alike

b. sure to have similar dispositions

c. always equal in mental capacity

d. never exactly alike 27. .....

Part Three. Completion

Directions: Supply the word or expression required to complete each of the following statements.

Sample:

1. The green coloring matter in plants is called .... 1. chlorophyll

---

1. Pasteur's work on microörganisms showed that they must come from other .... microörganisms. 1. ....
2. Every higher animal begins its life as a(n) .... 2. ....
3. The .... is an egg-laying mammal 3. ....
4. Types of mammals which give birth to partially developed young and carry them about in pouches are called .... 4. ....
5. The process by which birds keep fertilized eggs at a constant, fairly high temperature is called .... 5. ....
6. A small species of tropical fish which gives birth to living young is the .... 6. ....
7. A gamete is a(n) .... 7. ....
8. Every organism begins life as a .... 8. ....

9. The part of the seed which develops into the roots of the plant is the .... 9. ....

10. The male sexual organ of a flower is the .... 10. ....

11. In a grafting operation, the plant which receives the new shoot is called the ..... 11. ....

12. Asexual reproduction is found only among the .... forms of animal life. 12. ....

13. Apple trees and wild hawthorn trees are fairly closely related. It .... (would or would not) be possible to graft apples on a wild hawthorn tree. 13. ....

14. The process of .... is more rapid and reliable than cultivation by planting seeds in the soil. 14. ....

15. A strawberry plant reproduces by means of .... 15. ....

16. Offspring usually do not conform closely to the Mendelian ratios unless .... numbers are involved. 16. ....

17. When two pure-bred plants with contrasting characters are cross-bred, the trait which is hidden in the resulting offspring is known as a(n) .... trait. 17. ....

18. When several genes are transmitted as though

[illegible] ....
[illegible] ....
[illegible] ....
[illegible] ....
[illegible] ....
[illegible] ....
[illegible] ....
[illegible] ....
[illegible] ....
[illegible]

they were a single gene, they are said to be .... 18. ....

19. An insect which has been the subject of numerous experiments concerning heredity is the .... 19. ....

20. Genes are independent physical units which do not lose their identity at any time. This fact explains Mendel's law of .... 20. ....

21. Most changed genes are .... (dominant, recessive). 21. ....

Part Four. Cross-out

Directions: Cross out any endings to the statement which would make it false.

Sample:

1. An insect is
    - a. ~~a weed~~
    - b. an animal
    - c. an animal with a hard covering
    - d. ~~a chemical compound~~

---

1. Reproduction of living things comes from
    - a. weeds
    - b. sea plants
    - c. chemicals
    - d. clay casts
    - e. eggs

2. A person may inherit from his parents and ancestors
    a. his intelligence
    b. the build of his body
    c. a knowledge of mathematics
    d. the ability to do mathematics
3. The difference between body cells and germ cells is that
    a. germ cells give rise to sperms and eggs
    b. body cells are larger
    c. body cells have a greater number of chromosomes
    d. germ cells have twice the number of chromosomes
    e. germ cells divide by mitosis
4. A living person may be produced
    a. from his mother
    b. from an egg
    c. from a lump of dirt
    d. by the stork
5. Eggs are produced by
    a. hens
    b. ducks
    c. horses
    d. birds
    e. mosses
6. Flowers develop at some time on
    a. maple trees
    b. lilacs

c. sea weed

d. ragweed

e. poison ivy

7. Peach trees are often grafted because

a. they are more likely to be satisfactory

b. they produce fruit quicker than if raised from seed

c. they can not be raised from seed

d. they require less labor and care

8. Potatoes

a. cannot be raised from seeds

b. are more quickly raised from cutting off and planting the "eyes

c. do not have a blossom

d. must be raised from seeds

9. Plants may develop from

a. seeds

b. dirt

c. runners

d. water

e. stems

10. Animals which give their young little care succeed in maintaining their species because

a. they produce a great many young

b. they are more able to take care of themselves when born or hatched

c. they live longer

d. they live in the semi-tropics

Part Five. Matching

Directions: In the parenthesis before each item in column A, write the number of the item in column B which is most closely associated with it.

Sample:

Column A

(4) Characteristic of a monocot stem

(2) Growing region of a dicot stem

(3) Opening of a stem

Column B

1. annual rings
2. cambium
3. lenticel
4. rind
5. stoma

Column A

( ) Part of the seed containing stored food

( ) Union of egg and sperm

( ) Part of the stamen that bears pollen grains

( ) Transfer of pollen from anther to stigma

( ) Stem grafted upon another stem

( ) Underground stem

( ) Tuber

( ) Method of asexual reproduction in which a branch is bent down to the ground to take root

( ) Restoration of part of body

( ) Most common method of reproduction in a yeast

Column B

1. anther
2. budding
3. conjugation
4. cotyledon
5. fertilization
6. layering
7. pistil
8. pollination
9. regeneration
10. rhizome
11. scion
12. tuber
13. white potato

Column A

( ) Helped to disprove spontaneous generation

( ) The basic unit of living things

( ) External fertilization

( ) Descriptive term applied to animals whose eggs are fertilized within the reproductive tract of the female

Column B

1. bird
2. frog
3. Mendel
4. oviparous
5. Redi
6. single cell
7. tissue
8. viviparous

Column A

( ) Time required for an embryo to develop

( ) Descriptive term applied to animals that lay eggs

( ) Absorbing region in the membrane that surrounds the mammalian embryo

( ) Cell formed by the union of two gametes

( ) Reproductive cell

( ) Sperm producing organs of a male animal

( ) Union of two cells or gametes neither of which can be distinguished as male or female

( ) Spore cases growing on fungi

( ) Process by which sports are produced

( ) Organism that departs abruptly from parental types and breeds true thereafter

Column B

1. conjugation
2. gamete
3. gestation period
4. incubation period
5. mutant
6. mutation
7. ovaries
8. oviparous
9. placenta
10. sporangia
11. testes
12. viviparous
13. zygote

Column A

( ) Offspring that lacks pure unit characters and develops from mixed stock

( ) Characters that are concealed in a hybrid

( ) Transmission of certain characters from parent to offspring

( ) Bearers of hereditary characters

( ) Determiners of unit characters

( ) Science that deals with the improvement of society through environment

( ) Science that deals with the improvement of society by means of heredity

Column B

1. chromosomes
2. dominant
3. eugenics
4. euthenics
5. genes
6. heredity
7. hybrid
8. recessive

Part Six. Sequence

Directions: Read the statement preceding each group of items and notice that the items are arranged at random. Indicate the natural or logical order of the items by placing the numbers 1, 2, 3, 4 in the accompanying parenthesis.

Sample:

1. Arrange the following forms of life according to degree of specialization in reproduction, beginning with the least specialized:

(4) rose	(3) fern
(1) Protococcus	(2) moss

---

1. Arrange these methods of reproduction in proper sequence, beginning with the least complex method:
    - ( ) spores
    - ( ) cell division
    - ( ) fertilization
    - ( ) conjugation
2. Arrange the following steps in the growth of a bean seed in the order of occurrence:
    - ( ) formation of roots
    - ( ) formation of leaves
    - ( ) development of stem
    - ( ) absorption of water
3. Arrange the following in order of the amount of parental care given, beginning with the least:
    - ( ) man
    - ( ) fish
    - ( ) robin
    - ( ) horse
4. Arrange these plants in order of the distance to which their seeds might be dispersed, beginning with the plant whose seeds travel the greatest distance:
    - ( ) milkweed
    - ( ) coconut
    - ( ) wild bean
    - ( ) corn
5. Arrange the following in the order of parental care given to eggs and young, beginning with the one giving the most time:
    - ( ) honey bee
    - ( ) paradise fish
    - ( ) dog
    - ( ) kangaroo
6. Steps in the conjugation of spirogyra in a proper sequence:
    - ( ) contents of one cell empty into other plant

( ) tubelike projection sent out from cell walls
( ) zygote is formed
( ) tubelike projections meet

7. Steps in the life cycle of a moss plant, beginning with the step after fertilization:

( ) asexual generation produced
( ) underground stem developed
( ) sexual generation is formed
( ) spores formed

8. Arrange the structures in the body of a male frog in the order in which sperms pass through them:

( ) testes
( ) ureters
( ) cloaca
( ) sperm ducts

9. Arrange the steps in bud-grafting in proper sequence:

( ) T-shaped incision made in stock
( ) bud inserted in proper place
( ) bud removed from parent plant
( ) bud securely wrapped

10. Arrange steps in the life cycle of a flowering plant in proper sequence, beginning after the pollen ripens:

( ) pollen tube develops
( ) seed is formed
( ) cross-pollination takes place
( ) sperm nucleus united with egg nucleus

11. Arrange the structures of a mold plant in the order in

which they are produced when a new plant begins to form, beginning with the matter growth of rootlike structures:

( ) individual rootlike structures

( ) spore case

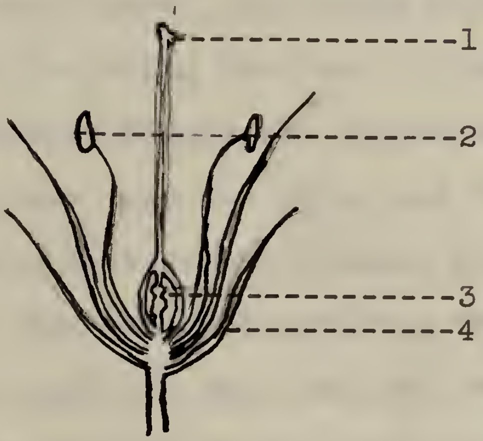
( ) mycelium

( ) spore

Part Seven. Diagrams

Label the numbered parts of the following diagrams.

A. Diagram of flower



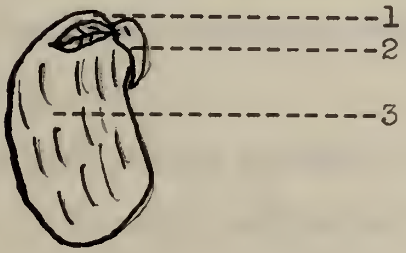
1. ....

2. ....

3. ....

4. ....

B. Sketch of internal view of bean seed



1. ....

2. ....

3. ....

CHAPTER III

EVALUATION OF THE TEST

Validity and Reliability

The test and its scoring.-- At the beginning of the unit mimeographed copies of the test were given to the pupils with the direction that they were to answer all of the questions whether they were sure of the answers or not. They were also informed that this test would not count as a part of their mark. Two class periods of sixty minutes each were used in giving the test. Most of the pupils finished twenty minutes before the period ended. At the end of the unit the same test was given and the mark obtained was included as a part of their grade on the entire unit.

The items which constitute the test were selected from questions made out when the unit was planned. These questions were grouped on the basis of which ones were relative to a given item in the delimitation of the unit. Then, from the various groups, questions were selected and compiled to form the test.

Answers were to be placed at the right-hand side of the paper since it is more convenient for the student and it makes the scoring easier for the teacher.[1] For the most

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[1] Ernest W. Tiegs, Tests and Measurements for Teachers, Houghton Mifflin Company, Boston, 1931, p. 263.

part the responses were to be made by underlining, or numbering, in preference to writing.[1]

The scoring of this test is objective and it can be readily accomplished by indicating on an unused test the correct response to each item. This insures an exact "match" when it is laid on the pupil's test for correction and incorrect items may be conveniently marked.

Reliability of the test.-- Two factors which influence the reliability of a test are objectivity and length. The objectivity of the test has been mentioned in the above paragraphs. It is agreed that the longer a test is made the more reliable it becomes. The fact that two class periods were to be used for test purposes caused the test to be limited to two hundred items.

The coefficient of reliability of the test was figured out by taking the "chance halves" of the test.[2] First, the score on each half before the unit was studied was counted for each student and the coefficient of correlation between the "chance halves" of the test by the Spearman-Rank formula was 0.88 and with the Spearman-Brown Prophecy formula the correlation was 0.94 (Table 1). Secondly, the same thing was done after the unit had been studied. In this case the correlation by the Spearman-Rank formula was 0.76 and it

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[1] Ibid, p. 265

[2] Ibid, p. 82

Table 1. Test scores on "Chance Halves" and correlation of "Chance Halves" before study of the unit.

Pupil (1)	Total of odd numbered (2)	Total of even numbered (3)	Difference between odd and even (4)	Differences squared (5)
1	42	43	1	1
2	30	30	0	0
3	43	39	4	16
4	41	35	6	36
5	42	47	5	25
6	37	41	4	16
7	38	37	1	1
8	34	30	4	16
9	35	37	2	4
10	39	34	5	25
11	34	29	5	25
12	27	24	3	9
13	33	33	0	0
14	34	36	2	4
15	34	33	1	1
16	37	38	1	1
17	35	31	4	16
18	35	28	7	49
19	17	22	5	25
20	19	21	2	4
21	38	28	10	100
22	34	39	5	25
23	23	22	1	1
24	29	28	1	1
25	39	29	10	100
26	24	22	2	4
27	23	20	3	9
28	22	21	1	1
29	26	22	4	16
30	29	28	1	1
31	25	20	5	25
N=31				$549 = \Sigma D^2$

Table 1. (concluded)

Correlation of "Chance Halves" of test before the unit was studied

(a) by Spearman-Rank Formula:[a]

$$\rho = 1 - \frac{6\Sigma D^2}{N(N^2-1)}$$

$$\rho = 1 - \frac{6(549)}{31(961-1)}$$

$$\rho = 1 - \frac{3294}{29760}$$

$$\rho = 1 - .12$$
$$\rho = 0.88$$
$$r = 0.89$$[b]

(b) by Spearman-Brown Prophecy Formula:[c]

$$r_x = \frac{nr}{1 + (n-1)r}$$

$$r_x = \frac{2(.89)}{1 + .89}$$

$$r_x = \frac{1.78}{1.89}$$

$$r_x = 0.94$$

was 0.86 by the Spearman-Brown Prophecy formula (Table 2). The estimated reliability of the entire test is 0.86 (Table 2).

Validity of the test.-- A test is valid if it measures what it purports to measure. The items for this test were obtained by selecting materials before the unit was even

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[a] Henry E. Garrett, Statistics in Psychology and Education, Longmans, Green and Co., New York, 1926, p. 190.

[b] Ibid, p. 192.

[c] Ibid, p. 269.

Table 2. Test scores on "Chance Halves" after study of the unit.

Pupil (1)	Total of odd numbered (2)	Total of even numbered (3)	Difference between odd and even (4)	Differences squared (5)
1	21	21	0	0
2	29	26	3	9
3	28	23	5	25
4	37	27	10	100
5	32	30	2	4
6	32	38	6	36
7	38	32	6	36
8	33	37	4	16
9	41	39	2	4
10	41	36	5	25
11	35	44	9	81
12	41	35	6	36
13	42	41	1	1
14	46	43	3	9
15	44	44	0	0
16	37	38	1	1
17	47	41	6	36
18	49	55	6	36
19	51	44	7	49
20	47	44	3	9
21[a]	60	37	23	509
22	52	42	10	100
23	54	48	6	36
24	48	44	4	16
25	56	48	8	64
26	56	49	7	49
27	54	52	2	4
28	57	52	5	25
29[a]	58	50	8	64
30	47	49	2	4
31	55	53	2	4
32	59	52	7	49
33	59	56	3	9
$N=33$				$1446=\Sigma D^2$

---

[a] Two pupils entered the class four weeks after the study of the unit commenced.

Table 2. (concluded)

Correlation of "Chance Halves" of test after the unit was studied

(a) by Spearman-Rank Formula:[a]

$$\rho = 1 - \frac{6\Sigma D^2}{N(N^2-1)}$$

$$\rho = 1 - \frac{6(1446)}{33(1089-1)}$$

$$\rho = 1 - \frac{8676}{35904}$$

$$\rho = 1 - .24$$

$$\rho = 0.76$$

$$r = 0.78$$[b]

(b) by Spearman-Brown Prophecy Formula:[c]

$$r_x = \frac{nr}{1 + (n-1)r}$$

$$r_x = \frac{2(.76)}{1+.76}$$

$$r_x = \frac{1.52}{1.76}$$

$$r_x = 0.86$$

presented to the students. The materials were carefully examined to make certain that they were well distributed over the statement of the unit, its delimitation, and the incidental learning products.

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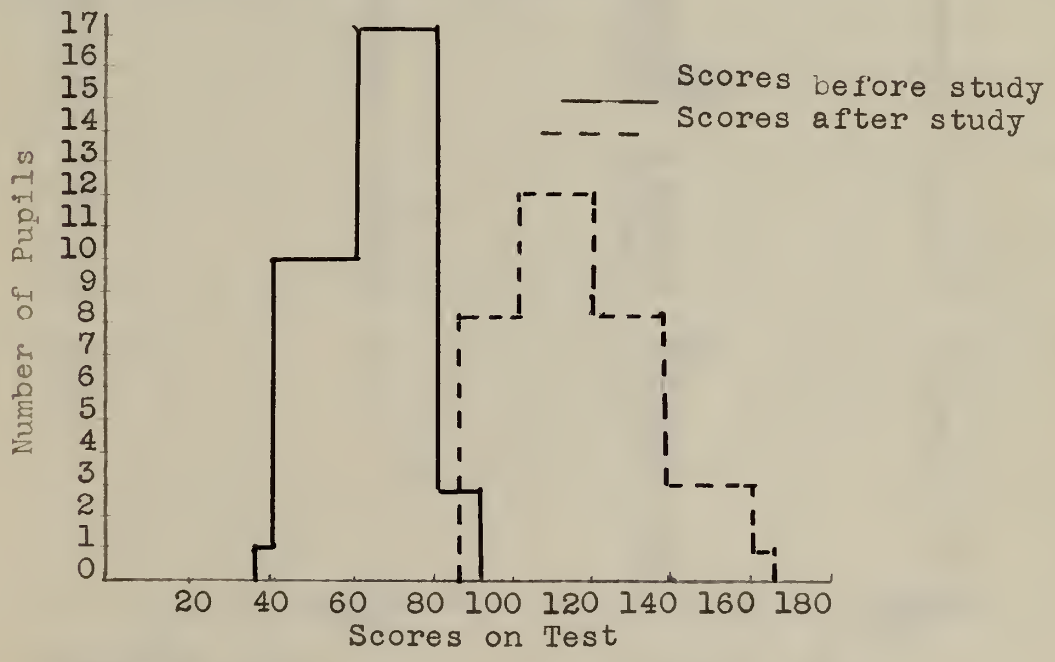
[a] Ibid, p. 190.

[b] Ibid, p. 192.

[c] Ibid, p. 269.

Growth indicated.-- A comparison of the total scores before the study of the unit (Table 3) shows that learning took place as indicated by the raising of the mean from 64.5 before study of the unit to 115.3 after study of the unit. Before the unit was studied the highest score was 89 and after it was studied the highest score was 161. The lowest score after study of the unit was only two points below the highest one before the students had studied the unit.

The relative growth of the class is more clearly indicated in the following histogram:



HISTOGRAM 1. RELATIVE GROWTH SCALE

Subjective observations.-- One of the older pupils who had returned from the armed services decided to plant bean seeds in different kinds of soil and also to use different fertilizers. He had never before shown any interest in

Table 3. Comparison of test scores before and after study of the unit.

Scores Before Study (1)	Number of Pupils (2)	Scores After Study (3)	Number of Pupils (4)
89	1	161	1
85	1	151	1
82	1	150	1
76	1	147	1
75	1	131	1
73	2	130	1
72	1	129	2
70	1	127	1
69	1	125	1
67	2	122	1
66	3	121	1
64	1	119	1
63	3	115	3
60	1	111	1
57	2	108[a]	1
51	1	107	2
48	1	105	1
46	1	103	2
45	2	100	1
43	2	98	1
40	1	97[a]	1
39	1	96	1
		95	1
		94	1
		93	1
		91	1
		87	1
	N=31		N=33
Mean[1] is 64.5		Mean is 115.3	

---

[a] Two pupils entered the class four weeks after the study of the unit commenced.

[1] Ibid, p. 8.

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farming, but a spell of damp weather which rotted his seeds did not discourage him and at last he had the satisfaction of getting noticeable results before frost killed his plants. In the spring he decided to set out a garden. Here was one known case in which a pupil received stimulation in a new activity which promises to hold his interest and may be profitable to him in the future.

Many of the pupils became interested in biography through the thrilling activities of George Washington Carver. Throughout the year they often preferred to select biographies to read instead of short encyclopedic articles.

Two of the boys as a result of their visit to a nursery developed an interest in plants and have made plans to work at the Connecticut State Experimental Station for the summer.

The motion pictures From Flower to Fruit and Romance in a Pond and the picturoll How Animals Reproduce Themselves were presented as an integrated part of the class activities and they aroused a larger number of questions than pictures did later in the year.

In conclusion.-- Despite the unfavorable fact that this unit was given early in the fall before the students had a real chance to become somewhat familiar with the study of living things, and that the method of teaching was entirely new to the pupils, the results have shown mastery and appreciation of the subject matter. If the unit had been given

Implies work other than unit is required before unit could work effectively. Not complete unit then.

later in the year, the results would no doubt have been more noticeable because of the maturity of the pupils and the fact that there would not have been so many new words and terms to be learned at one time.

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Motion Pictures on Reproduction and Heredity

Heredity (Erpi) SO 533 A.M.N.H.	1 reel
Mammals, Reproduction Among SO 575 A.M.N.H.	1 reel
Embryo, the Development of a Bird Number 335 A.M.N.H.	1 reel
*Flower to Fruit, From Number 328 A.M.N.H.	1 reel
Housefly, The (l.h.) Number 323 A.M.N.H.	1 reel
Reproduction Among Mammals (Erpi) YS-108 Y.M.C.A. Film Service	1 reel
*Romance in a Pond (l.h. of common Newt) GS-118 Y.M.C.A. Film Service	1 reel
In All His Glory (Pollination & Fertilization) GS-132 Y.M.C.A. Film Service	1 reel
The Iris Family (From bulb to bloom) GS-134 Y.M.C.A. Film Service	1 reel
Seed and Seed Dispersal (Erpi) M-445 Y.M.C.A. Film Service	1 reel
Time Lapse Studies of Plant Growth U. S. Dept. of Agriculture	1 reel (silent)

Ovulation (Not available at present) U. S. Dept. of Agriculture	2 reels (silent)
In the Beginning (Ovulation, fertilization and early development of mammalian egg) U. S. Dept. of Agriculture	2 reels (sound)
Wizards of Svalof (On genetics, mostly of wheat) U. S. Dept. of Agriculture	2 reels (sound)
How Seeds Germinate U. S. Dept. of Agriculture	1 reel (silent) (35 mm. only)

Picturoll

*How Animals Reproduce Themselves Society for Visual Education	35 mm. film
Mammals, the Hairy or Furry Animals Society for Visual Education	35 mm. film
Some Insect Life Histories Society for Visual Education	35 mm. film
Kangaroo Junior Steps Out (Development of a baby kangaroo) Society for Visual Education	35 mm. film

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